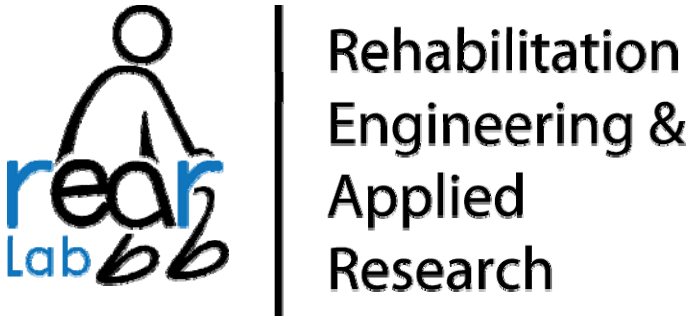

How manual wheelchairs are used during everyday mobility

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Why understand mobility device use in everyday environments?

- Clinicians and users
  - Relating a clients use (or anticipated use) relative to others may better inform decisions about which devices to select.
- Manufacturers and Suppliers
  - Better information about how products are used can inform design of their products and compare products within their offerings.
- Payers
  - Any data that relates mobility to health or independence or secondary complications should inform policy. We can and should learn more about use to better distinguish users, and therefore coverage.

How far do people walk?

Subject set	# subjects	Mean Daily Steps	95% CI
ALL	6101	9,448	8,899-9,996
Men	1325	8,412	7,165-9,661
Women	2338	8,735	7,821-9,648
US	2107	7,271	6,123-8,418
Japan	2783	9,317	8,403- 10,231

6-7.5 km/day

Bohannon RW. Number of pedometer-assessed steps taken per day by adults: a descriptive meta-analysis. *Phys Ther. 2007;* 87:1642–1650.

How far & over what duration do **Manual Wheelchair** Users Wheel

Study	Population	Daily Distance	Daily Time	Daily Speed
Karmarkar et al.	VA nursing homes	1.5 km	n/a	0.48 m/s
Levy et al.	Adults	1.45 km	n/a	n/a
Tolerico et al.	Athletes	2.5 km	48 min	0.8 m/s
Cooper et al.	Children	1.6 km	n/a	0.67 m/s
Oyster et al.	SCI	1.9 km	47 min	0.63 m/s
Summary	--	**1.5 – 2.5 km**	**47.5 min**	**0.5 – 0.8 m/s**

Karmarkar, A. M., D. M. Collins, et al. (2010). Disabil Rehabil Assist Technol **5(6): 428-437.**

Levy, C. E., M. P. Buman, et al. (2010). Am J Phys Med Rehabil **89(8): 625-634.**

Tolerico, M. L., D. Ding, et al. (2007). J Rehabil Res Dev **44(4): 561-572.**

Cooper, R. A., M. Tolerico, et al. (2008). Am J Phys Med Rehabil **87(12): 977-983.**

Oyster, M. L., A. M. Karmarkar, et al. (2011). Arch Phys Med Rehabil **92(3): 484-490.**

How far & over what duration do **Power Wheelchair** Users Wheel

Study	Population	Daily Distance	Daily time in motion	Avg Speed
Cooper et al., 2002	17 VA athletes & community users	2.5 km	n/a	0.42 m/s
Sonenblum, et al., 2008	25 community users	1.9 km	61 min	0.32 m/s

Mean values: will be important later

Cooper, et. al, (2002) Arch Phys Med

Sonenblum, et. al, (2008) Arch Phys Med

Compare wheelchair users to ambulatory cohorts with disabilities

Comparing daily distances of movement

- Able-bodied : 6-7.5 km/day
- Amputees: 2-2.4 km/day
- Cane users: 1-1.3 km/day
- Manual wheelchair users: 1.5-2.5 km day
- Power wheelchair users: 1.9- 2.5 km/day

Can we begin to define “mobility disability” by this discrepancy?

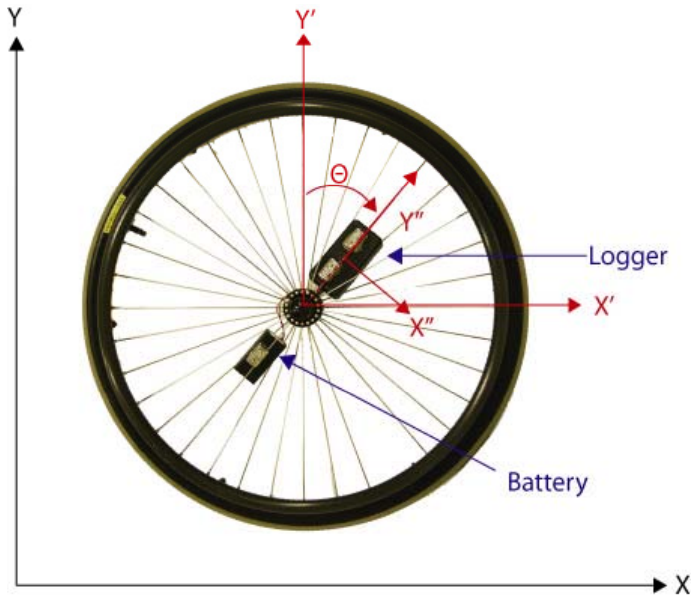
How people move about is different than *how far* people move

Distance, time moving & bouts of mobility

- Three constructs, 2 are commonly described
- *Distance* and *time* are very highly correlated
- *Bouts* of movement
  - Represent transitions between activities

Methods: Measuring Wheelchair Movement

- A solid-state, triaxial, MEMS-based acceleration sensor with a ±2g range mounted on one wheel
- Sampling rate: 10 Hz



Characterizing Mobility using **Bouts of Mobility**

- Travel between activities
- START
  - Travel at 0.12 m/s for at least 5 seconds
  - Equates to .27 mph for at least 0.6 m or 2 ft
- STOP
  - Travel less than 0.76 m over 15 seconds
  - Allows for pauses in transitions

Characterizing Manual Mobility

- **Subjects**

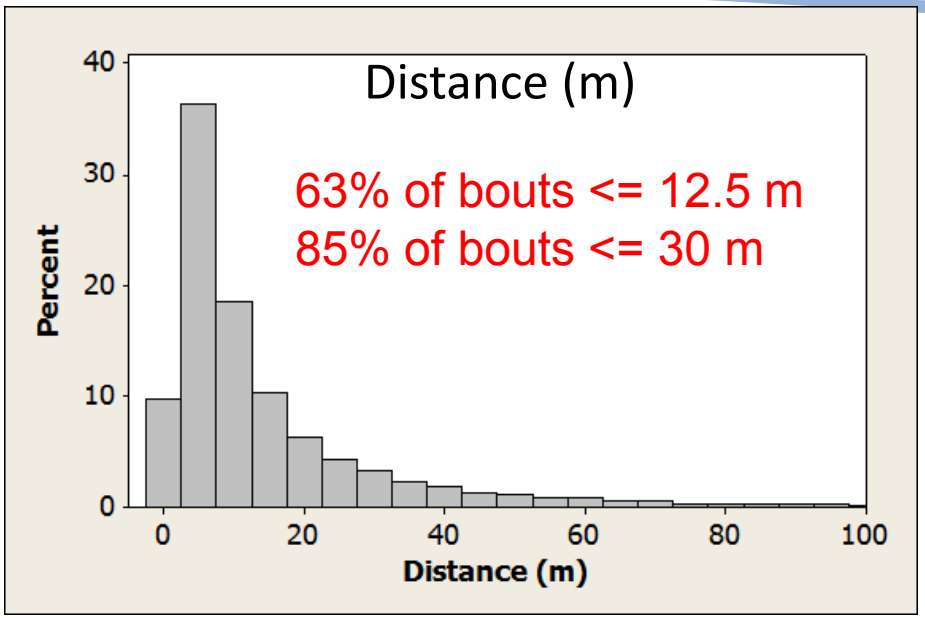
- 28 adults, 22 to 91 (median 35)
- Multiple diagnoses (SCI = 20)
- Manual wheelchair used as the primary mobility device

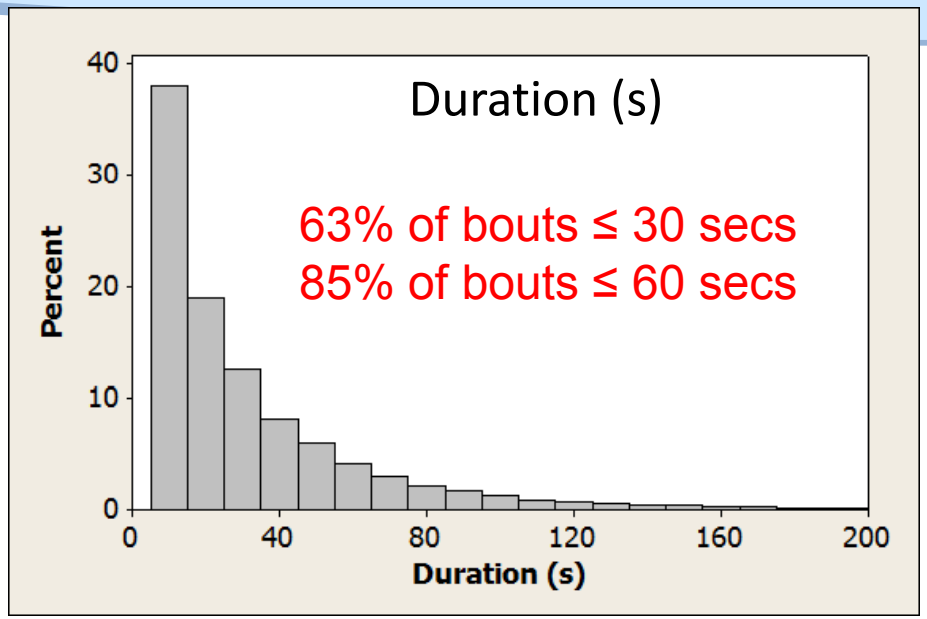
- **Protocol**

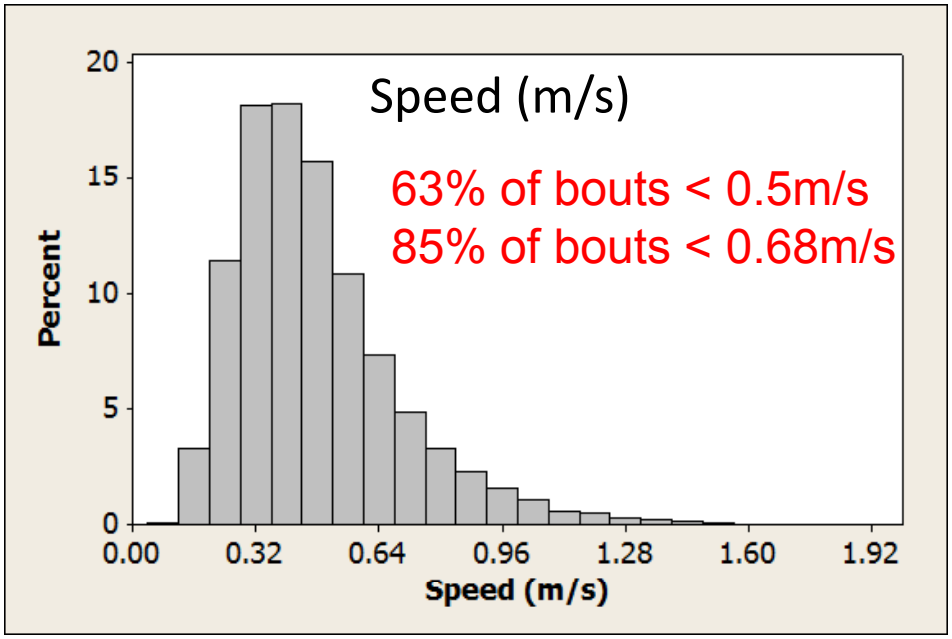
- Data collection period varied between 2 & 16 days per subject

- **Record Summary**

- 29256 bouts of mobility
- 296 hours of wheeling
- 595 km wheeled
- 342 subject-days







Distance and Duration are highly skewed, whereas velocity is more normally distributed

Bouts of manual wheelchair movement

Daily Activity

	Median	Minimum	Maximum
Bouts per day	90	3	235
Daily distance	1.6 km	7.1 m	10.5 km
Daily time moving	54.3 min	30 s	208 min

Bout Descriptions

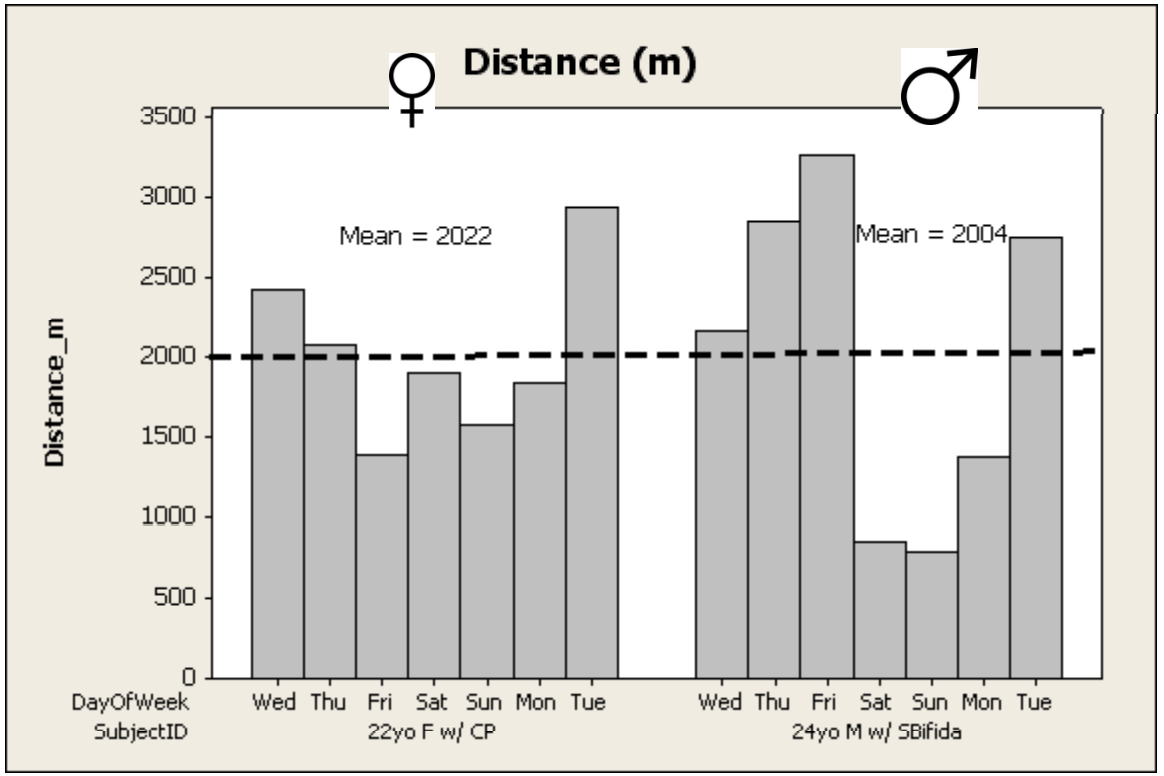
	Median	Minimum	Maximum
Bout duration	21.3 s	5.0 s**	40.3 min
Bout distance	8.6 m	0.8 m	3.83 km
Bout speed	0.43 m/s	0.09 m/s	1.9 m/s

≈85% of bouts are shorter than 60 seconds & 30 meters at a rate <0.7 m/s

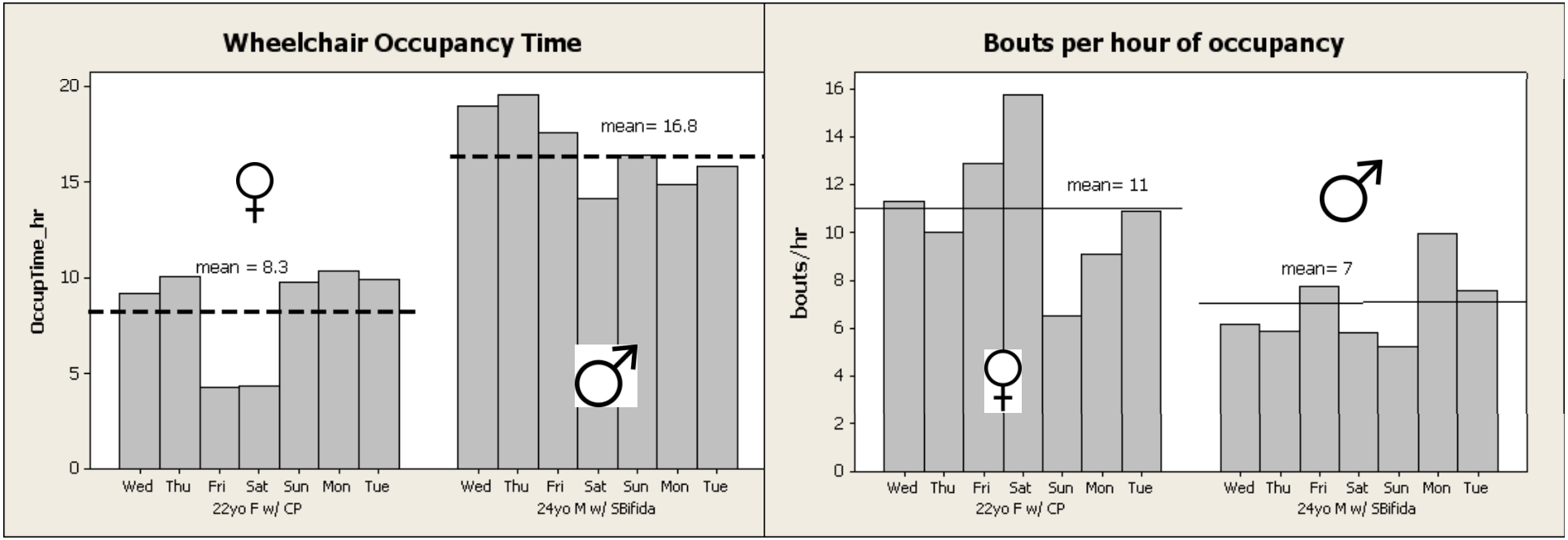
Let’s look deeper at 2 people

- Female
- 22 years old
- Cerebral palsy
- Employed
- Independent in transfer
- Cannot stand or ambulate

- Male
- 24 years old
- Spina Bifida
- Employed
- Independent in transfer
- Cannot stand or ambulate



- Same mean daily distance over a week
- 2 km is about **35-40%** of a typical US ambulating adult
- ♂ shows a typical pattern with depressed weekend activity
- ♀ shows less day to day variance (25% vs 50% C.V.)



- Both full time users in wheelchairs for many hours
- ♂ pretty much in chair while awake
- ♀ appears to transfer into and out of chair (*she is employed*)

- ♀ more activity while in chair
- Does ↑ activity rate mean ↑ exertion?
- Stunning that a ♂ in his 20's seems to 'hang out' more

Power Wheelchair Movement
vs.
Manual Wheelchair Movement

Median Bout Characteristics

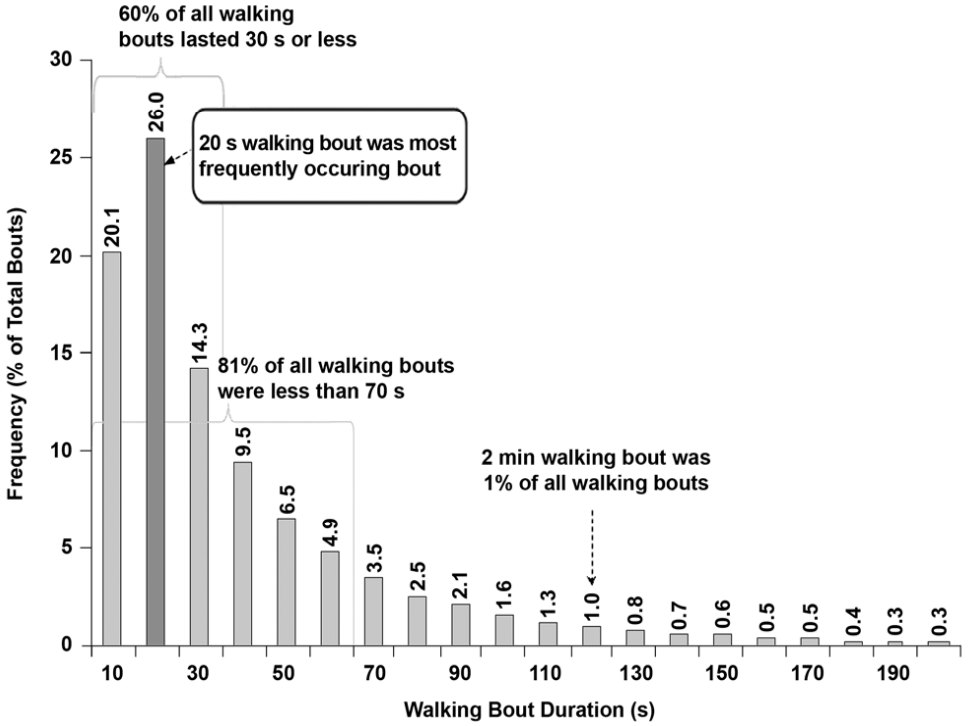
	Manual	Power
Distance (m)	8.6	3.9
Duration (sec)	21	18
Speed (m/s)	0.43	0.25

What factors might explain these differences?

How people walk

Levine, JA, et. al; Diabetes. 2008

- **On average, a participant took 47 walks per day**
- **85% were <15 min in duration**
- **88% occurred at < .9 m/s (2 mph)**



Orendurff MS, et. al; JRRD 2008

- **90% of walking bouts <100 steps**
- **40% of bouts <= 12 steps**
- **3% of bouts lasted >= 3 min**

Note the similarity with wheelchair movement:
small bouts predominate

Wheeling and Walking

- Similar profiles
- Daily movement is dominated by short bouts

Walking (Orendurff)	Manual WC
60% ≤ 30 s	63% ≤ 30 s
81% ≤ 70 s	85% ≤ 60 s

Conclusion: Manual wheelchair users are typical Americans

But only in how they move, not how much

Findings &
Why Should we care?

- Variation of wheelchair use is great across & within people
  - Complicates ability to represent 'norms' parametrically
- Wheelchair users have depressed mobility
  - Construct of 'mobility disability"
- Short bouts of movement dominate wheelchair usage
  - Wheelchair users move about like ambulators
- Short bouts of mobility are defined by starting, stopping and turning
  - Starting handrim forces are higher than continuation forces
  - Maneuvering needs to be a key functional consideration
- Application of findings can inform research into
  - propulsion efficiency
  - secondary complications of wheelchair use
  - clinical prescription of wheelchairs

The Team

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- Jayme Caspall

The Disclaimer

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